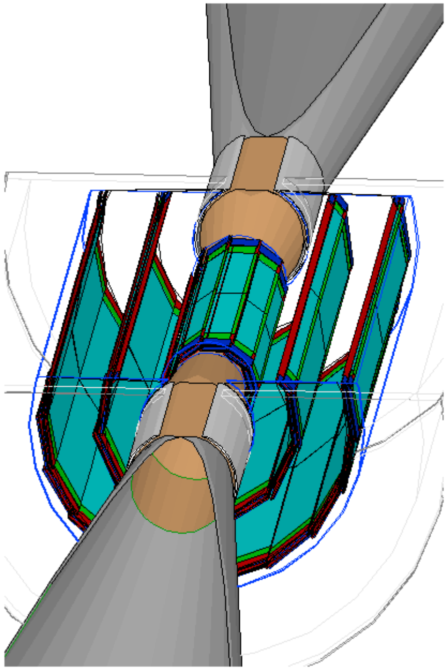

ILD vertex detector: VXD Integration

Status 2011 April 18

J.Baudot, for the IPHC group
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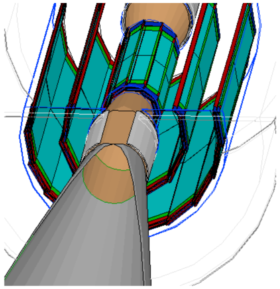
- ✗ Overview
- ✗ Mechanics
- ✗ Cooling
- ✗ Cabling
- ✗ Material budget



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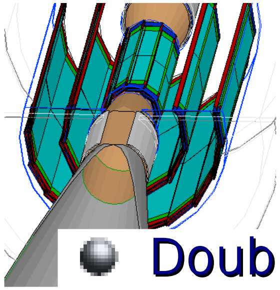
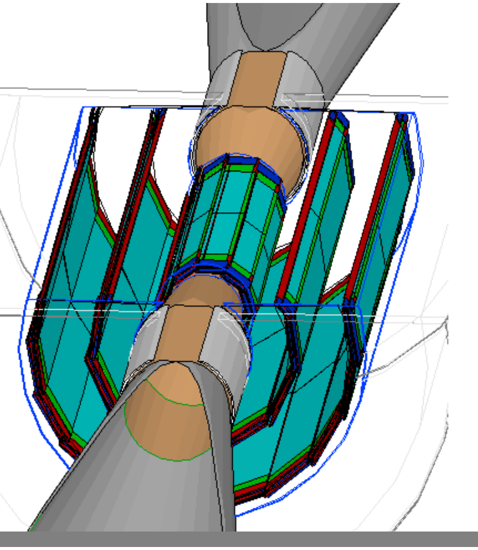


Geometry - 1

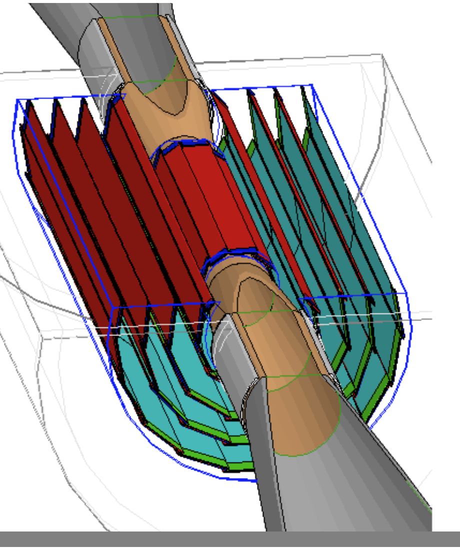
Double sided ladders

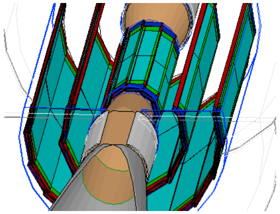
- Ladder is equipped with two layers of sensors
  - ~2mm separation between two layers in one ladder
  - Material budget [LOI target) 0.16% X0
- 3 layers



Single sided ladders

- Ladder is equipped with one layer of sensor
  - Material budget (LOI target) 0.11% X0
- 5 layers





Geometry - 2

Geometry definition

- ✗ Sensitive width of ladders is fixed, an additional 0.5 mm with is provisioned for electronics
- ✗ Number and orientation of ladders are computed to reach 100% coverage with some overlap
- ✗
- ✗ Note: **a module** is a basic sensing element,
  ~125mm long, equipped with one readout cable
  - ➔ A double sided ladder requires 2 modules, one one each side
  - ➔ A 250 mm long ladder requires 2 modules for one length

layer	radius (mm)		width (mm)		length (mm)		# ladders		# modules	
	single	double	single	double	single	double	single	double	single	double
1	15	16/18	11	11	125	125	10	10	10	20
2	26		15		250		11		22	
3	37	37/39	22	22	250	250	11	11	22	44
4	48		22		250		14		28	
5	60	58/60	22	22	250	250	17	17	34	68
total							63	38	116	132

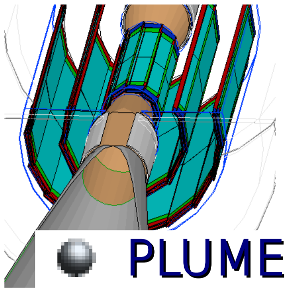
Sensor options

- **CMOS pixel sensors**
  - ✗ Power dissipation ~100mW/cm^2
    - ➔ Full detector O(1) KW while active
    - ➔ Factor 1/50(100) for average
  - ✗ Servicing required
    - ➔ ?

- **CCDs**
  - ✗ FinePixelCCD, ISIS
  - ✗ CCD to be kept at low temp
    Power dissipation ? mW/cm^2
  - ✗ Servicing required
    - ➔ ?

- **DEPFET sensors**
  - ✗ Power dissipation ? mW/cm^2
  - ✗ Servicing required
    - ➔ Read-out ASICs

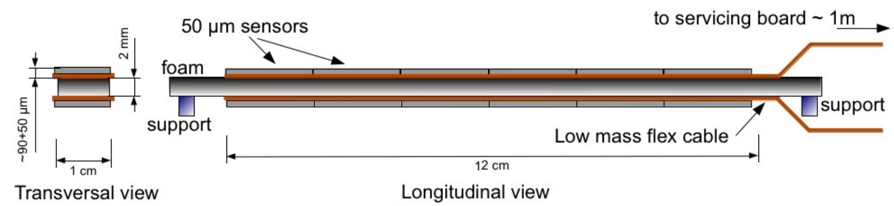
! INCOMPLETE SLIDE !



Ladder prototypes

PLUME project

- ✗ Bristol U. DESY, IPHC, Oxford U.
- ✗ Running from 2009 to 2012
- ✗ Double sided ladder with 0.3% X0 goal
- ✗ Focus on CMOS sensors
  BUT should accommodate other technologies

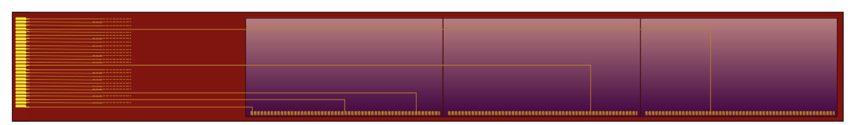


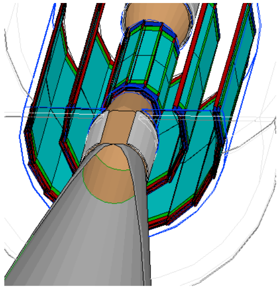
SERWIETE project

- ✗ IPHC, IKFrankfurt, IMEC Leuven
  - ➔ EU-FP7, Hadron Physics 2 project
- ✗ Embedding the sensor inside kapton & metal layers
  - ➔ Benefit from ultimate CMOS thickness (20-30µm)
  - ➔ Allow very thin metal traces down to 1µm
  - ➔ Material budget for 1 module *O*(0.1) % X0

Studies foreseen

- ✗ Power pulsing
- ✗ Alignment (AIDA project in EU-FP7)
- ✗ Lorentz force impact





- Overview
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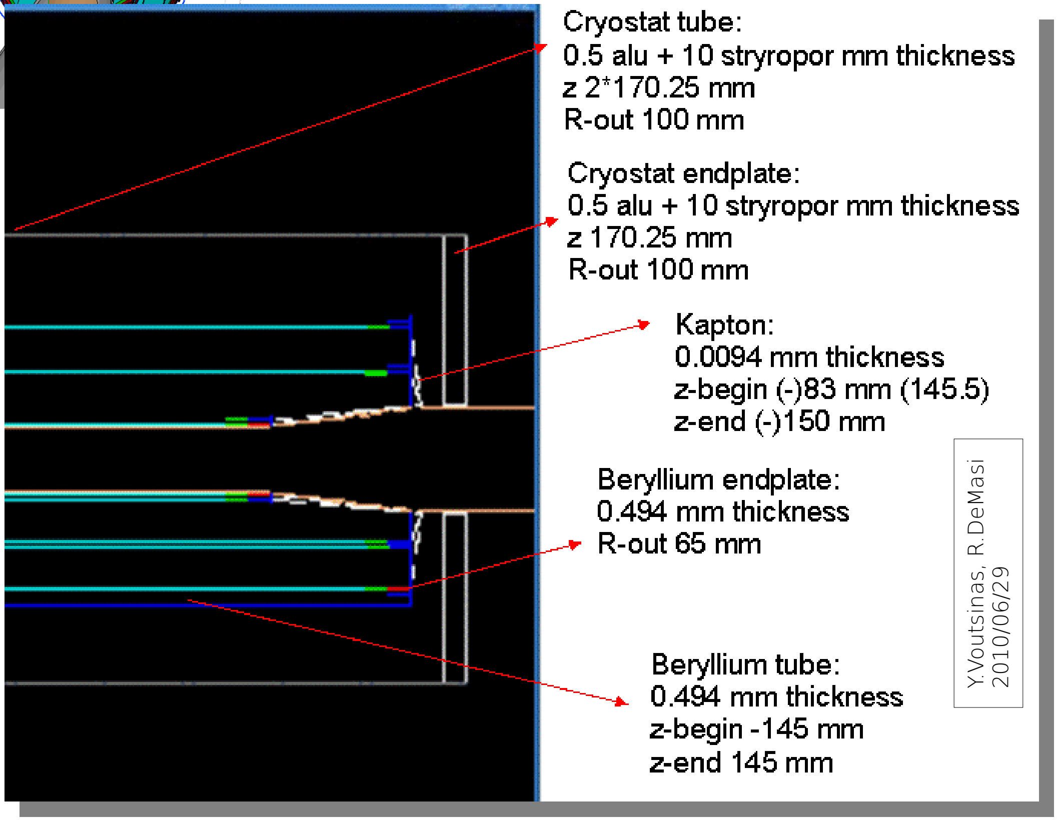
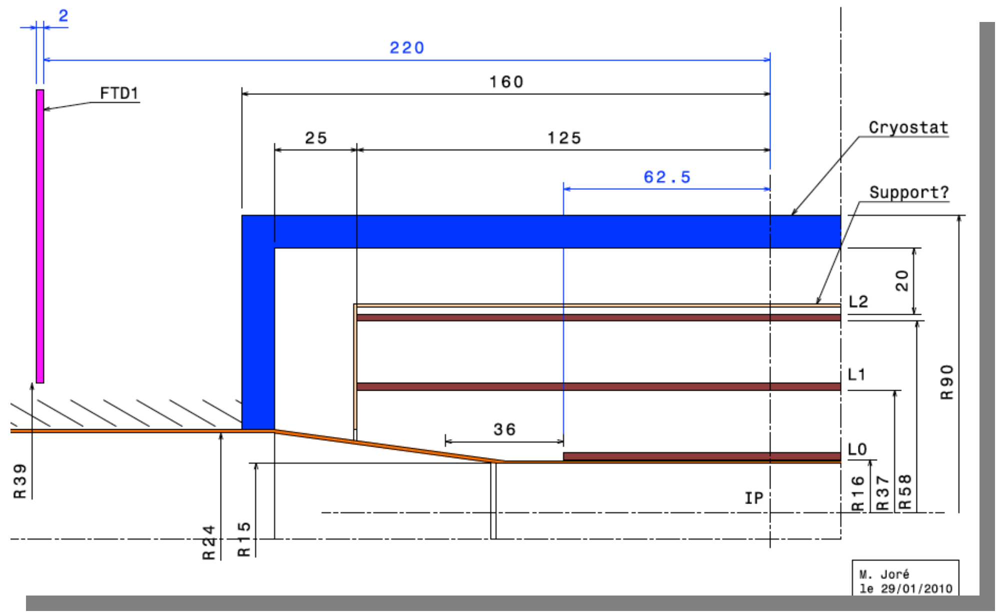
Mokka vs Mecha. model



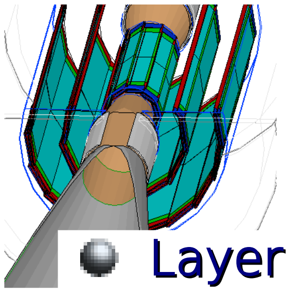


Mokka (VXD03)

- ✗ Simplistic double-sided ladder = 2xsingle-sided ladder BUT radiation length match LOI target
- ✗ Cryostat larger R(+10mm) & z (+10mm) / mecha. model

Mechanical model

- ✗ Miss ladder fixtures on support
  - ➔ Support z is -20mm / Mokka
- ✗ Miss kapton cables from ladders to pipe
- ✗ Support radius lower (-5mm) / Mokka



Supporting the VXD

Layer support

- ✗ 1st layer is mounted on the beam pipe
- ✗ 2nd & 3rd layers mounted on the Beryllium support
- ✗ Beryllium support clamped on beam pipe
- ✗ No study on the impact of beam pipe deformation
- ✗ No technical drawing available (manpower)

Weight

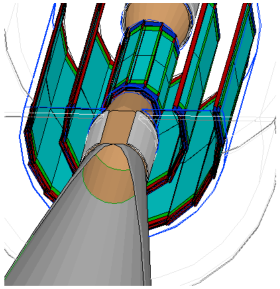
- ✗ Ladders:
- ✗ Beryllium support:
- ✗ Cryostat:
- ✗ Cables (up to cryo.):

Mechanical alignment

- ✗ Initial survey (<100µm) should be good enough
- ✗ Note: IR light go through CMOS sensors (both sides)

Mounting concept

- ✗ No detail work done



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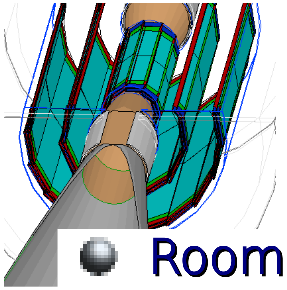


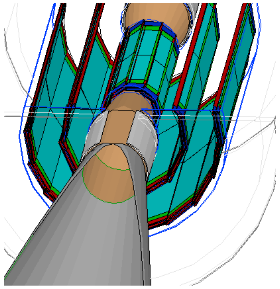
Two options

Room temperature operation

- CMOS-like sensors
- Passive cooling
  - Air flow ~ 1 m/s (for mech. Stability)
  - Sensor Temp~10-30 °C
  - Air Temp. Under study
- No real cryostat, nevertheless
  - Faraday cage needed
  - May require air separation / SIT
  - Some thickness of aluminium
- Tubes required on beam pipe
  - Diameter ? mm

Negative temperature operation

- FinePixel-CCD-like sensors
- Active cooling required
  - $C0_2$ evaporation in tubes
  - Sensor Temp~ -(5-15) °C
- Real cryostat needed
  - Backbone 0.5 mm aluminium
  - Isolation material = 10mm styropor
  - 0.5(?) % X0
- Tubes required on beam-pipe
  - ?



- Overview
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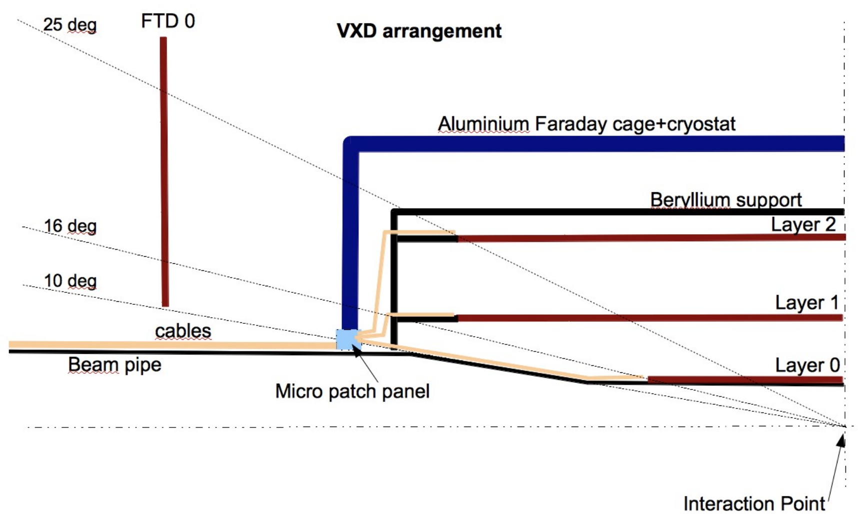
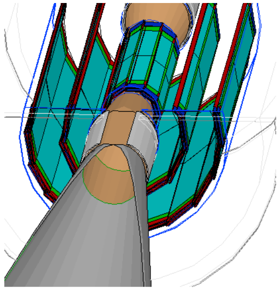
Cables inside the cryostat

- **Position**
  - ✗ Flat kapton cables running from each ladder to the cryostat at the beam pipe level where they are connected to a small patch panel (cannot go through the cryostat due to faraday cage spec.)
- **Electrical spec.**
  - ✗ Kapton cable: ~ 50 µm thick, ~2cm wide
    - ➔ Realistic mat. budget including metal traces ~0.02 to 0.03 %X0
    - ➔ In Mokka, only 50 µm of kapton = 0.018 % X0
  - ✗ One such cable per module, so PER SIDE
    - ➔ 5 cables running at 10 deg along the beam pipe
    - ➔ 60 cables crossing acceptance between 10-25 deg

Taking into account overlaps:
[10, 16] deg : ~0.15% X0
[16, 25] deg : ~0.05% X0



Reminder: the two sides are symmetric!

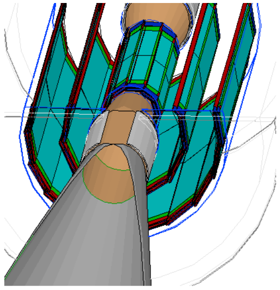


Cable outside the cryostat - 1

Cables running on the beam pipe, outside the cryostat, ~4m

Powers

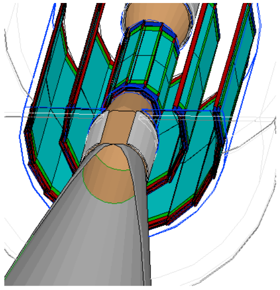
- ✗ Assumptions are:
  - ➔ Sensors are active only during a period of few ms (around the train)
  - ➔ Total <u>instantaneous</u> power between 300 to 600 W (300 Mpixels with 1 to 2 µW/pixel)
    - This power range should cover all technologies and geometry (3 double or 5 single layers)
  - ➔ Neglecting the power required from potential additional boards located on the cryostat
  - ➔ Powering voltage is 3 V
  - ➔ Cable length is 4 m
  - ➔ Allowed voltage drop < 0.1V
  - ➔ Powering from both side of the detector, so current load (100 to 200 Amps) is divided by 2/side
- ✗ Copper cables:
  - ➔ Section: 0.4 to 0.8 cm^2
  - ➔ Weight: 4 to 8 g/cm
- ✗ <u>Note:</u> the cables dissipate an instantaneous power of (0.1 V x 100 to 200 A = 10 to 20 W) only during the ms when the sensors are functional. So, considering power pulsing, the average power dissipated by these cables is at most 5% of the instantaneous power.



Cable outside the cryostat - 3

Cables running on the beam pipe, outside the cryostat, ~4m

- **Control signals**
  - ✗ ~15 lines with ~15 Amps total per side
  - ✗ To limit voltage drop to 100 mV with copper cables
    - ➔ Cable copper section ~ $5mm^2$
    - ➔ equivalent to a weight load ~0.5 g/cm



Cable outside the cryostat - 3

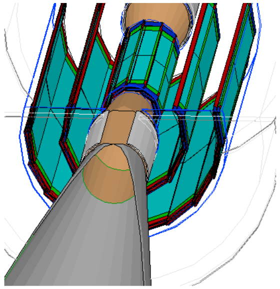
Cables running on the beam pipe, outside the cryostat, ~4m

Data

- ✗ Remember that the data rate is dominated by the $e^{\pm}$ from beamstrahlung
  - ➔ Total hits expected in average per train ~ 3.3×10^6 (for 5 single-layers) or 4.7×10^6 (for 3 double-layers)
  - ➔ Taking into account Poisson fluctuation requires a factor x3
  - ➔ Security factor wrt simulations requires another factor x3
  - ➔ Maximum expected hits overall the detector ~ $45\text{x}10^6$ hits/train
- ✗ Assuming 100 bits to encode one hit (based on an average of 5 pixels per hit)
  - ➔ Total detector information is 4 Gbits for one train (1ms) (this includes security factors)
  - ➔ Non-uniform distribution of ladders:
    at r~15mm: 130 Mbits/ladder/train, at r~37mm: 30 Mbits/ladder/train, at r~48mm: 7 Mbits/ladder/train
- ✗ Assuming we can use optic fibers featuring 10 Gbits/s:
  - ➔ OPTION with instantaneous (during 1 ms) readout: data rate ~ 4 Tbits/s → 200 fibers per side
    clearly, this option requires either a serialization at the support and/or fibers with higher rate
  - ➔ OPTION with delayed readout (during 200 ms): data rate ~ 20 Gbits/s → 1 fiber per side
- ✗ Difficult yet to estimate the material budget from fibers (assuming 1g/cm for glass):
  - ➔ Probably inner layers will have 1 fiber at each ladder end -> 20 fibers per side
  - ➔ The rest of the layers can be read-out with about 10 fibers
  - ➔ A LOT OF QUESTIONS STILL TO BE ANSWERED THERE

Cables for cooling

- No idea yet, sorry



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